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HOW TO INCREASE THE YIELD OF WHEAT IN CALIFORNIA

BY

G. W. SHAW

Hauling grain to warehouse.

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HOW TO INCREASE THE YIELD OF WHEAT IN CALIFORNIA

BY
G. W. SHAW.

The particular feature which has dominated grain culture in California, and on the Pacific coast generally, has been mass production, rather than maximum production per unit of area or quality of product. But with the inevitable ultimate deterioration of soil under such a practice, heightened by the encroachment of other crops, there has been a notable falling off in the production *in toto,* as well as in the yield per acre, during recent years. While grain farming on an extensive scale is not an industry to be particularly encouraged when natural conditions are such as to make more intensive crops safe, yet it is still, and is destined to be for all time, a very important industry in California; and as one of the staple crops of a general farm is worthy of not only much encouragement but also the greatest aid that can be given it by scientific research. Further, on account of climatic and topographical conditions there will always be large areas in the state in which cereal culture will be the principal interest.

How to produce more grain of better quality per acre, then, is a very pertinent problem. Under a special appropriation of the State Legislature the Agricultural Experiment Station of the University of California has conducted for the past five years investigations having in view a solution of this problem, and some very important practical and scientific results have been secured. It is the aim of this bulletin to set forth in as brief a manner as possible some of the more important results bearing upon the question of an increased yield, leaving the more intricate problem, the effect of environment upon the gluten content of wheat, almost wholly for discussion in a subsequent publication. On account of the limited funds available for printing, it will be possible to set forth little more than a summary of the work at this time.

NOTE OF ACKNOWLEDGMENT.—The writer wishes to express his indebtedness to Messrs. A. J. Gaumnitz, J. T. Bearss, and H. F. Blanchard, who have been entrusted with the execution of the details of the experiments which are discussed herein.

Fig. 1.—Birdseye view of California Cereal Station, Sacramento Valley.

Fig. 2.—General view of grain plats on the Tulare Station, 1908.

The investigations covered by this report are in general based upon results and observations covering a long period. For a limited time a portion of the work was conducted in co-operation with the Bureau of Plant Industry of the United States Department of Agriculture.

Both the field and laboratory investigations have covered a wide range. They embrace the relative value of deep vs. shallow plowing, early vs. late seeding, drill vs. broadcast seeding, trials with fertilizers, the effect of certain rotation schemes, the improvement of the soil through green-manuring, moisture conservation, the treatment of grain for the prevention of smut, the value of exchanging seed, cleaning the land from weeds both by cultural methods and the use of chemical sprays, and finally, variety trials and the development of better types of grain than those commonly grown. In the study of the general question of environmental influence upon the quality of wheat, and also the selection work involving an increase of the gluten content, there has of course been a large amount of chemical work required. Questions involved along these lines have been the influence upon the gluten content of the length of the growing period, of the time of harvest, of the time of seeding, of the time the wheat plant receives its moisture, the influence of sunshine and of the composition of the soil. The environmental question as affecting the gluten content will be the theme of a separate report.

In this report an effort has been made to so correlate the cultural results and observations that they may be of immediate benefit to the California grain growers, in effecting improvement in soil fertility, increasing the yield of grain, and improving the milling quality of the grain produced.

It should be said that these results should be considered as simply the foundation for more extensive work. *The element of time is an all-essential one for the solution of such problems as these.* This would be true even though the problem was merely the development of grain giving higher yields, but, with the introduction of the problem of increasing the gluten content, the element of time is of even greater importance.

The old methods of grain growing still persist in California. They are generally very simple and very crude. At first satisfactory returns were obtained because of an unusually fertile virgin soil. At the outset there was an annual cropping of the land to the cereals with no attempt to either rotate crops or restore any of the humus that such a system destroys. In order to cover as large an

acreage as possible the crudest methods of culture were practiced. The practice consisted simply of three- or four-inch plowing, broadcasting the seed, and harrowing it in. But little attention was paid to the selection of pure seed, and far too often the growers purchased a second or a third grade seed under the false notion that anything that would sprout was good enough.

The more important changes which have taken place since the introduction of the above named crude practices have been the replacing of the header and stationary thresher by the combined harvester, and the quite general introduction of the practice of summer-fallowing of land.

The development of the combined harvester has without doubt decreased the cost of production where grain is harvested upon a large scale, but it has at the same time tended to encourage a desultory system of culture, rendered the fields very foul both by the general distribution of weed seeds and because by the time the grain is harvested in this manner practically all the serious weeds have fully ripened their seed; and further, on account of the long time the grain is left in the field after maturity, has tended to seriously increase the loss from shattering of the grain from the wind. This latter condition is especially true in the Sacramento Valley. It is very questionable, then, as to whether the combined effects of these undesirable factors have not more than offset the decreased cost.

The summer fallow practice was introduced for two reasons: first, it was an attempt to save as much of two season's precipitation as possible for the production of a single larger crop; second, to clean the land of weeds resulting from continued grain culture. The latter effect has been largely offset by the use of the combined harvester.

The shallow preparation of land and the continual practice of burning off the straw has had a very bad effect upon the humus content of the top foot of the soil, which in turn has so affected its physical condition, generally speaking, as to materially reduce its moisture capacity and seriously affect the yield of grain. Further, the earlier seeding made possible by the summer fallow practice has also reduced the quality of the grain, as shown by the analyses of a large number of early and late seeded grain.

During recent years, mainly as a result of the reduction in size of some grain farms, and the educational efforts throughout the state conducted by the University of California, there has been an increase of the depth of plowing on the part of some farmers, but in general the same careless methods of culture still hold.

To summarize, the general effect of the past and present methods has been the development of a poor physical condition of the land, largely as a result of the depletion of the humus, until the soil refuses to produce profitable crops of the commonly grown varieties of wheat under the old system of farming, and, besides, the soil has been made very foul with weeds.

CULTURAL EXPERIMENTS.

DEEP VS. SHALLOW PLOWING.

At the outset of these investigations a large number of cultural experiments were planned, principally in the Sacramento Valley. It is almost the universal practice in California to give grain land a very shallow preparation, probably 90 per cent. is seldom, if ever, plowed to exceed three or four inches in depth. Although this is so generally the practice, yet it is diametrically opposed to the most fundamental principles of "dry-land farming," so-called, *viz.*, securing a deep penetration of water and retaining it in the soil till late in the season for properly maturing the crop and to encourage deep rooting.

On the University Farm at Davis, where the average precipitation is about 20 inches, forty trials of deep vs. shallow preparation of land for grain have been tried within the past three years and the results are set forth in the following table:

TABLE I.—RESULTS OF DEEP VS. SHALLOW PLOWING FOR GRAIN.

AVERAGE OF 40 TRIALS.

	Wheat bu.	Barley bu.	Effect on succeeding crop of Barley
Deep plowing	29.78	75.98	25.36
Shallow plowing	21.67	69.30	17.32
Gain	8.11	6.68	8.04
Percentage increase	37.40	9.70	46.50
Increased money value	$7.78	$3.34	$4.02

It should be stated that this deeper preparation of land for grain applies either to the plowing for summer fallow or for seeding previous to the middle of January. If land is to be prepared later than such date then a more shallow preparation with thorough working of the surface is undoubtedly preferable.

Deep plowing to enable quick and deep penetration of water, and followed by immediate subpacking of the soil, either by the use of a disk set rather straight, or on light soils a sub-surface packer, and finally a thorough preparation of the surface seed-bed, are fundamental principles of grain production.

The average yield of wheat in the State for the past three years has been 14.5 bushels per acre. On the Cereal Stations, over the same period, the average yields, including all varieties, some of which were very poorly adapted to California conditions and therefore giving light returns, has been as follows:

	Wheat, bu. per acre	Barley, bu. per acre
Tulare	35.2	53.4
Davis	40.4	45.4
Ceres	33.2	19.1
Average	36.3	39.3

In this connection it must be remembered that neither irrigation nor fertilization has been practiced on these tracts except in certain plats which are not included in the averages. This increased average yield has been almost entirely due to a deeper plowing than is customary, a better preparation of the seed bed, and a well cultivated summer fallow. On the experimental tract at the University Farm Davis, the average yield of barley for the last three years has been 45.4 bushels per acre. The same land at Davis under more shallow preparation, over the same period has returned a yield of 37.9 bushels per acre of barley.

Much of the grain land of the State at present, as a result of continued shallow culture, has developed a very tenacious plow-sole which materially lessens its ability to absorb moisture rapidly and freely. On such lands it may not be advisable to plow to the full depth of eight inches at one operation, but rather to *increase the depth gradually until eight-inch plowing can be the regular practice.* In many localities a plowing to a depth of twelve inches is advisable, especially if the land has become exceedingly compact and hard. While the benefits from deep plowing may not be so evident the first season, unless great care is taken to sub-pack the soil in order to establish good capillary connection in the undersoil, *the results are of permanent character.* The subsoil is materially benefited by aeration and other climatic influences, and the effects of deep plowing will be noticeable for several succeeding crops. For an illustration of this, note the residual effect of deep plowing on the barley crop as shown in Table I.

DISKING VS. PLOWING OF LAND FOR SPRING SEEDING.

When the season has far advanced before seeding particular care must be taken not to leave the soil so loose as to cause rapid drying out. Generally under such conditions the disk serves a better purpose

in the preparation of the land than the plow, even though the plowing be shallow. Several trials of this have been made and are set forth in the subjoined table.

TABLE II.—DISKING VS. PLOWING OF LAND FOR SPRING SEEDING.

	Land disked bu.	Land plowed bu.	Difference
1909	52.00	50.00	2.0
1910	45.80	41.50	4.3
Average	48.90	45.75	3.1

THE EFFECT OF INCREASING THE HUMUS OF THE SOIL.

California soils in the grain growing sections are low in humus. For many years the writer has maintained persistently that *the maintenance and increase of the humus component of the soil is the most important single factor in California agriculture.* Humus is vegetable or animal matter in process of decay. Its presence in ample quantity in a soil means success; its lack means disaster, and this is particularly true in dry-land farming. *To lessen seriously the humus content of a soil is to lower the crop producing powers of the individual farm and impair natural resources.*

HUMUS benefits the soil physically:

(1) By increasing its water holding capacity.
(2) By increasing its warmth.
(3) By bettering its texture.

HUMUS benefits the soil chemically:

(4) By supplying nitrogen directly.
(5) By supplying phosphoric acid, potash, and lime directly.

HUMUS benefits the soil biologically:

(6) By affording food for micro-organic growth.

Very pertinent to this is an experiment described by Professor Cavanaugh, of Cornell Experiment Station. He undertook the analysis of soil from an orchard where three successive crops of crimson clover had been plowed under. In order to learn what change, if any, had been produced, another sample from the same field, but where no clover had grown, was also examined. These two samples were taken about 20 feet apart, and there was no reason to suppose that previous to the growing of the clover the soil in these two places was materially different. The amounts of moisture, humus and nitrogen, were determined.

The results were as follows:

	With no Clover Per cent.	After Clover Per cent.	Difference
Moisture	8.75	15.00	6.25
Humus	1.91	2.94	1.03
Nitrogen	.12	.21	.09

Possibly a more definite idea may be had of these differences if the increased amounts per acre are calculated. Since the soil was in an orchard, where the extreme depth of cultivation was about six

Fig. 3.—Pea crop to be turned under for increasing the humus supply of the soil. Yuba City Station.

inches, the samples were taken to that depth. The average weight of soils per acre for a depth of six inches is about 750 tons, or 1,500,000 pounds; 6.25 per cent. of this amount, in the case of moisture, would show an increased water-holding capacity of 93,750 pounds, or 46⅞ tons. This result was made possible by the increased amount of humus, and a careful system of surface tillage. If there had been no other benefit from this system of green-manuring than this increased power to hold moisture, it would have more than paid for seed and labor, for an extra forty-six tons of water is very convenient

in a dry time, and might easily be the turning point between success and failure.

Already the wheat soils of the San Joaquin Valley have had their humus content so seriously impaired as to render it extremely doubtful

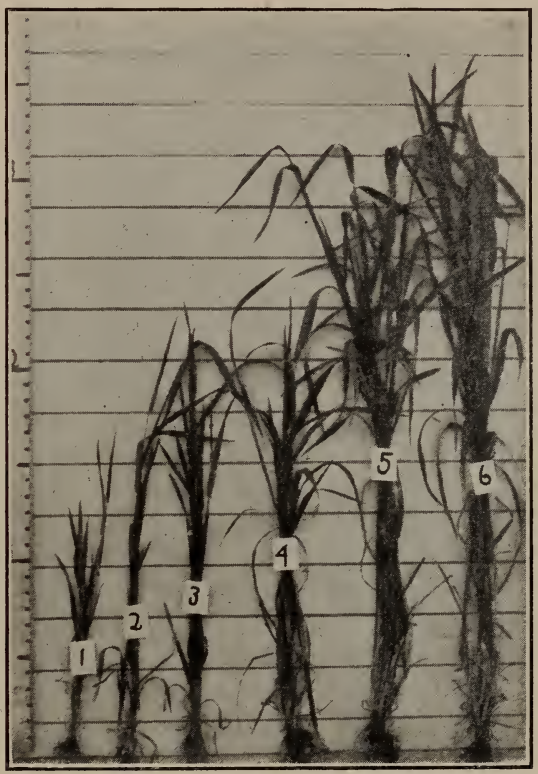

Fig. 4.—Wheat plants from six plats treated differently, showing comparative development: (1) from plat continuously seeded to wheat; (2) from plat bare-fallowed in 1908; (3) from plat upon which horse beans were grown and plowed under in 1908; (4) from plat upon which Canadian field peas were grown and plowed under in 1908; (5) from plat upon which rye and vetch were grown and plowed under in 1908; (6) from plat upon which rye was grown and plowed under in 1908.

if it is at all possible to produce three good successive crops of wheat upon the same land, largely on account of their lack of moisture-holding power. This is not equally true of the heavier soils represented by the University Farm at Davis.

Continued grain culture under shallow preparation over a long

period has seriously affected the naturally low humus supply of the grain lands. This condition has been rendered worse by the burning of the straw and biennial culture necessitated by a limited precipitation. The only way to either maintain or increase the humus supply is by the use of stable manure or the growing of green-manure crops to be turned under. The former is out of the question over any considerable area, and *the only recourse is the growing of green-manure crops to be turned under.*

Fig. 5.—Wheat growing on plat which has been continuously seeded to the same crop. (See figure 4 (1).)

At the outset of this work a scheme was laid out on each of the Stations to determine the most economical crop to be grown to accomplish this result, and the effect of such treatment upon the yield of grain. Essentially the same scheme was employed both in the San Joaquin Valley, on a sandy soil, and in the Sacramento Valley, on a heavy soil. While the trials have not been conducted sufficiently long to be beyond possibilities of slight errors, yet they are sufficient to give an idea of what may be reasonably expected from turning under green-manure crops and as a factor in increasing the grain crops of California should be given the closest attention.

In these experiments it has been the general practice to plow the land about eight inches deep at the time of turning under the green-manure crop, and then to be careful to so treat the land either with disk or sub-surface packer as to be certain to establish close contact of the soil with the green stuff turned under and to maintain proper capillary connection between the top soil and under soil. This is necessary to secure the most effective results from the green stuff and to prevent drying out of the top soil.

TABLE III.—EFFECT OF DEEP PLOWING AND GREEN-MANURE CROPS ON THE YIELD OF WHEAT ON SANDY SOIL IN SAN JOAQUIN VALLEY (CERES).

No. of Plat	Preceding treatment of crop	Yield per acre in bu. 1909	1910	2-yr. av.
1	Bare fallow	28.0	38.6	33.3
2	Horsebeans (turned under)	35.3	40.0	37.6
3	Canadian field peas (turned under)	33.7	39.3	36.5
4	Wheat after wheat	15.7	.....	15.7*
5	Rye and vetch (turned under)	50.7	57.3	54.0
6	Rye (turned under)	51.3	53.3	52.3

* One year only.

Illustrations showing the field appearance of the several tracts are shown as Figs. 5 to 9.

In discussing the results of this work in 1909, Mr. H. F. Blanchard, at that time in charge of the Ceres Station, says:

"The cultivation of the plats indicated in the table was as follows:

"In the fall of 1907 all of the plats were laid out on summer-fallow land and all were plowed to a depth of 6 inches and harrowed. Plat 1 was allowed to remain fallow. Plat 4 was sown to wheat. Plats 2, 3, 5, and 6 were sown, as indicated, to horse beans, Canadian field peas, rye and vetch, and rye alone. The vetch in plat 5 made a very poor stand, while the horse beans and peas made a fairly good stand. The stand of rye was excellent."

"In March, 1908, plats 1, 2, 3, 5, and 6 were plowed 8 inches deep, harrowed, and kept clean throughout the summer and fall. Plat 4, which yielded at the rate of 26 bushels of wheat to the acre, was double-disked immediately after the wheat was taken off."

"The first of December, 1908, all plats were plowed to a depth of 5 inches and sown to wheat. The resulting yields are given in Table III. In two years' time the plat continuously seeded to wheat has produced 41 bushels of wheat. However, the first year's yield, 26 bushels, was produced after summer fallow and the second year's yield, 15.66 bushels, shows a decrease of nearly half. It is quite probable that the third year will give a very low yield and that in a

Fig. 6.—Wheat growing on plats which had been barefallowed in 1908. (See figure 4 (2).)

Fig. 7.—Wheat growing on plat on which Canadian field peas were grown and plowed under in 1908. (See figure 4 (3).)

Fig. 8.—Wheat growing on plat on which rye and vetch were grown and plowed under in 1908. (See figure 4 (5).)

Fig. 9.—Wheat growing on plat on which rye was grown and plowed under in 1908. (See figure 4 (6).)

series of five years the quantity of wheat produced from continuously seeded plats would be much smaller than from the other methods of cultivation.''

''It follows, then, from this experiment, that deeply plowed summer fallow will give much better yields than shallow plowed, continuously cropped land. Plats 1, 2, 3, 5, and 6 were all plowed at the same depth, and the last four were fallowed also after turning under the green crops. The yields indicate that the addition of organic matter (humus) to the soil is beneficial in increasing the production of crops and that this increase is proportional to the quantity rather than the quality or kind of organic matter added.''

Fig. 10.—Plat 30, wheat after wheat, University Farm, Davis. Contrast with Figs. 11 and 12. (See Table IV.)

At Davis the general character of the cultivation has been the same on the several plats, and the results have been less striking only because the soil on that station is normally richer in humus and naturally more retentive of moisture.

The results in tabulated form are shown below:

TABLE IV.—EFFECT OF DEEP PLOWING AND GREEN-MANURE CROPS ON THE YIELD OF WHEAT ON HEAVY SOILS AT DAVIS, 1907-10.

Crop or treatment	Yield per acre bu.
Wheat after wheat	32.7
Wheat after fallow	41.6
Wheat after horsebeans (turned under)	43.1
Wheat after field peas (turned under)	43.3
Wheat after wheat	38.6
Wheat after horsebeans (turned under and followed by Kafir corn)	42.3
Wheat after rye and vetch (turned under)	44.4
Wheat after burr clover (turned under)	48.2

Fig. 11.—Plat 39, University Farm, Davis. Wheat after horsebeans (turned under) followed by Kafir corn. Contrast with Fig. 10. (See Table IV.)

Fig. 12.—Plat 41, University Farm, Davis. Wheat after turning under a crop of rye and vetch. Contrast with Fig. 10. (See Table IV.)

The inevitable conclusion from the experiments conducted at both of these stations along these lines is that *by means of deeper plowing and the growing of green-manure crops during the winter the yields of grain can be very materially increased.* It is certainly reasonable in the light of these experiments that by the adoption of better methods of culture, and improvement of the humus content of the soil by green-manuring, the average wheat yield of California can, without much trouble, be raised to nearly double what it is at present and at the same time the soil be put into a more favorable condition for other crops.

Fig. 13.—Canadian field peas to be turned under to increase the humus and the moisture capacity of grain land. University Farm, Davis, 1908.

CROPS TO BE USED FOR GREEN-MANURING.

A large variety of plants have been tried out for green-manuring purposes, either directly in this rotation scheme, or separately, but under the present condition of the seed market only a limited number of varieties are obtainable.

In the light of the experiments discussed above, *it appears that it is rather the mass of green stuff that can be introduced into the soil that counts, rather than the character of the material.* This is a condition which seems to hold at present, but probably is not likely to be permanently true. *The immediate effect of the green-manure stuff is to improve the moisture holding capacity,* and the evidence would

seem to show that this is the condition of first importance, and that the matter of direct nitrogen supply is of secondary consideration. Results secured with field peas or vetches would doubtless be more lasting in their effect, and the quality of humus better, but unfortunately there is much difficulty in securing a sufficient growth of either of these crops on many of the grain lands in their present physical condition. *The most favorable immediate results can probably be secured by the use of rye.* Under favorable conditions peas, seeded at the rate of one hundred pounds per acre, have given good results in the Sacramento Valley. The Niles pea is probably somewhat more favorable than the Canadian field pea, since it grows more rapidly and is somewhat earlier in maturing. On the lighter soil of the San Joaquin Valley, peas do not make as rank a growth as in the Sacramento Valley. A favorable mixture is peas and rye sown together at the rate of 60 pounds of peas and 30 pounds of rye per acre.

Under the present soil conditions, and to lay a foundation for the future use of peas or other legumes, winter rye is to be highly recommended. This should be seeded at the rate of 80 pounds per acre.

The essential thing is to secure the maximum growth of green stuff during the winter to be turned under in the early spring. The grower should use the plant which he finds will make the most rapid growth under his own conditions. Rye is usually a sure crop on any kind of soil; peas or vetches are less certain to make a large growth. But whenever possible to secure a satisfactory growth a legume is preferable, because it makes an addition of nitrogen to the soil, and thus improves its chemical as well as physical conditions.

Whatever crop is used it should be seeded as soon as it is possible to either shallow-plow or disk the land. If the land has been disked immediately after the removal of the grain crop, the green-manure crop can usually be seeded by December first, though occasionally it may be necessarily later. In the case of legumes it is not advisable to sow later than December fifteenth, but with rye the seeding may be done as late as January first. The crop should be turned under from the first to the middle of March, before the ground is too dry for deep plowing. The aim should be to secure as long a growing period for the green-manure crop as possible without leaving the ground so late as to prevent humification.

It is a great aid to early preparation of stubble land to disk the land immediately after the crop is harvested. This tends to conserve the residual moisture, and enables it to make use of the light fall precipitation, and furnishes a fine soil to be turned under in plowing, and it still further encourages the early germination of weed seeds.

THE USE OF COMMERCIAL FERTILIZERS ON GRAIN.

Among the cultural experiments a series of fertilizer tests was planned with the idea of ultimately securing answers to the following questions:

A. Does an increase in the available nitrogen in the soil increase the gluten of the wheat and the yield per acre?

B. What is the effect of an increase of lime upon the yield of grain both with and without the addition of nitrogen?

C. Does an increase in the nitrogen content of the soil in the presence of liberal amounts of phosphoric acid increase the gluten content of the grain, or the yield?

D. Does increasing the phosphoric acid increase either the gluten content or the yield of wheat?

E. Does increasing the potash supply, either alone or in combination with other materials, increase the gluten content or the yield per acre?

F. What is the relative value of nitrogen in nitrate of soda and in organic form (dried blood)?

G. Plats 23, 24, and 25 are to have legumes grown upon them every third year and the cereal crops the other two years, the latter crops to be fertilized with superphosphate and potash on the second crop after the legumes. The results of this plan of operation are to be compared with the average of the check plats and with 21 and 27.

For the purpose of answering these questions the following fertilizer scheme is being carried out:

TABLE V.—EXPERIMENT A—FERTILIZERS ON WHEAT.

UNIVERSITY FARM, DAVIS, 1907-10.

Plat No.	Treatment on one-twentieth acre plats	Av. yield for 3 yrs. Bu. per acre Wheat	Yield per acre, 1907-08 Barley
1	Nitrate of soda, 5 lbs.; hydrated lime, 132½ lbs.	39.6	22.1
2	Nitrate of soda, 5 lbs.	44.7	13.3
3	Hydrated lime, 132½ lbs.; nitrate of soda, 5 lbs.	28.8	12.8
4	Check; no fertilizer	30.1	13.6
5	Nitrate of soda, 5 lbs.; sulfate of potash, 6 lbs.	30.5	17.8
6	Nitrate of soda, 10 lbs.	35.0	15.6
7	Check; no fertilizer	35.3	13.9
8	Nitrate of soda, 5 lbs.; superphosphate, 20 lbs.	38.7	17.2
9	Nitrate of soda, 10 lbs.; sulfate of potash, 6 lbs.	27.7	17.2
10	Nitrate of soda, 10 lbs.; superphosphate, 20 lbs.	30.1	18.3
11	Check; no fertilizer	27.7	13.3
12	Superphosphate, 20 lbs.	30.4	15.5
13	Sulfate of potash, 6 lbs.	33.5	16.1
14	Check; no fertilizer	34.7	14.3

NOTE.—While a fertilizer scheme was originally planned for each of the stations, it finally developed that either the extreme weediness or the uneven character of the soil where the plats were located rendered the results untrustworthy, except on the University Farm tract.

Plat No.		Av. yield for 3 yrs. Bu. per acre Wheat	Yield per acre, 1907-08 Barley
15	Nitrate of soda, 5 lbs.; sulfate of potash, 12 lbs.	42.6	12.2
16	Nitrate of soda, 5 lbs.; superphosphate, 30 lbs.	35.5	17.8
17	Nitrate of soda, 10 lbs.; superphosphate, 30 lbs.; sulfate of potash, 6 lbs.	37.5	19.4
18	Nitrate of soda, 5 lbs.; superphosphate, 30 lbs.; sulfate of potash, 12 lbs.	36.1	15.0
19	Nitrate of soda, 5 lbs.; superphosphate, 30 lbs.; sulfate of potash, 12 lbs.	35.7	17.8
20	Nitrate of soda, 5 lbs.; superphosphate, 50 lbs.; sulfate of potash, 6 lbs.	36.5	18.3
21	Check; no fertilizer	34.5	13.9
22	Sulfate of potash, 6 lbs.; superphosphate, 30 lbs.	32.0	12.2
23	Dried blood, 7 lbs.; superphosphate, 30 lbs.; sulfate of potash, 6 lbs.	31.8	15.6
24	Legume, 1907-08; no fertilizer, 1908-09; superphosphate, 30 lbs.; sulfate of potash, 6 lbs., 1909-10	37.7	16.6
25	Superphosphate, 30 lbs.; sulfate of potash, 6 lbs., 1907-08; legume, 1908-09 (Canadian field pea); no fertilizer, 1909-10		
26	No fertilizer, 1907-08; superphosphate, 30 lbs., 1908-09; sulfate of potash, 6 lbs., 1908-09; legume, 1909-10		
27	Check; no fertilizer	34.4	15.0

The experiments have not yet been conducted a sufficiently long time to furnish conclusive data, yet the results for three years furnish certain indications which are suggestive, and from them the following tentative conclusion may be drawn.

THE GENERAL EFFECT OF NITROGENOUS FERTILIZERS ON THE YIELD OF WHEAT AT UNIVERSITY FARM, DAVIS.

The general effect of nitrate of soda upon the yield of wheat for the past three years on the plats at the University Farm at Davis is shown by collecting the yields as expressed above and comparing with their respective check plats.

Plats Receiving Nitrate of Soda.		Plats Receiving no Nitrate of Soda.	
No. of Plat	Yield per acre bu.	No. of Plat	Yield per acre bu.
1	39.66	3	32.96
2	49.66	4	35.31
Average for 2 years	42.16		34.14
6	34.90	7	35.28
5	30.47	13	33.47
10	30.01	12	30.42
17	37.48	19	35.72
8	38.65	12	30.42
Average for 3 years	34.30		33.06

This comparison would seem to show that in the case of wheat the increased yield per acre that can be secured from the use of nitrates on soils similar to those at the University Farm is but slight. It should be said in this connection that nitrification has been found to have taken place to an unusual depth—12 feet or more—on these soils, hence it is not strange that the above results should show such a small increase from the use of nitrates.

In the matter of nitrate nitrogen as compared with organic nitrogen in a complete fertilizer there has been a distinct advantage in favor of the former as shown below:

	Plat No.	Yield
Nitrogen as nitrate in complete fertilizer	20	36.51
Nitrogen as blood in complete fertilizer	23	31.88
Gain		4.63

GENERAL EFFECT OF PHOSPHATIC FERTILIZERS ON THE YIELD OF WHEAT AT UNIVERSITY FARM, DAVIS.

Collecting the results from Table V in a similar manner for the plats carrying phosphates in the form of superphosphates we obtain as follows:

Plats Receiving Superphosphate.		Plats Receiving no Superphosphate.	
No. of Plat	Yield per acre bu.	No. of Plat	Yield per acre bu.
8*	44.65	2*	44.66
10	30.01	6	34.90
12	30.42	11	27.70
20	36.51	18	36.05
22	32.02	13	33.47
Average for 3 years	32.24		33.03

* 2 years only, not included in average.

Here it is found that for the past three years the general effect of phosphates upon the yield of wheat on these soils has been negative rather than positive.

THE GENERAL EFFECT OF POTASH UPON THE YIELD OF WHEAT AT THE UNIVERSITY FARM, DAVIS.

Plats Receiving Sulfate of Potash.		Plats Receiving no Sulfate of Potash.	
No. of Plat	Yield per acre bu.	No. of Plat	Yield per acre bu.
5*	30.5	2*	44.7
9	27.7	6	35.0
13	33.5	14	34.7
15	42.6	5	30.5
19	35.7	18	36.1
Average	34.9		34.1

* 2 years only, not included in average.

The general effect of the potash fertilizer has been very slight in these soils during these trials.

The total general effect on the fertilized plats has only been an increase of 0.8 bushel per acre, which of course is altogether too small to warrant their use on these soils for wheat production.

FERTILIZER TRIALS UPON BARLEY AT UNIVERSITY FARM, DAVIS.

In the season of 1907-08 similar trials of fertilizer were made upon barley with the following results:

GENERAL EFFECT OF NITROGENOUS FERTILIZER ON BARLEY AT UNIVERSITY FARM, DAVIS.

Plats Receiving Nitrate of Soda.		Plats not Receiving Nitrate of Soda.		
No. of Plat	Yield per acre bu.	No. of Plat	Yield per acre bu.	Gain or Loss
1	22.1	3	12.8	+9.3
2	13.3	4	13.6	—0.3
5	17.8	13	16.1	+1.7
6	15.6	7	13.9	+1.7
6	15.6	2	13.3	+2.3
6	15.6	4	13.6	+2.0
8	17.2	12	15.5	+1.7
9	17.2	5	17.8	—0.6
9	17.2	13	16.1	+1.1
10	18.3	8	17.2	+1.1
10	18.3	12	15.5	+2.8
17	19.4	19	17.8	+1.6
18	15.0	22	12.2	+2.8
Average	17.1		15.0	+2.1

GENERAL EFFECT OF PHOSPHATES UPON THE YIELD OF BARLEY AT UNIVERSITY FARM, DAVIS.

Plats Receiving Superphosphate.		Plats Receiving no Superphosphate.		
No. of Plat	Yield per acre bu.	No. of Plat	Yield per acre bu.	Gain or Loss
12	15.5	11	13.3	+2.2
8	17.2	2	13.3	+3.9
10	18.3	6	15.6	+2.7
16	17.8	2	13.3	+4.5
20	18.3	18	15.0	+3.3
19	17.8	15	12.2	+5.6
22	12.2	13	16.1	—3.9
Average	16.7		14.1	+2.6

GENERAL EFFECT OF POTASH UPON THE YIELD OF BARLEY AT UNIVERSITY FARM, DAVIS.

Plats Receiving Sulfate of Potash.		Plats Receiving no Sulfate of Potash.		
No. of Plat	Yield per acre bu.	No. of Plat	Yield per acre bu.	Gain or Loss
5	17.8	2	13.3	+4.5
9	17.2	6	15.6	+1.6
13	16.1	14	14.3	+1.8
15	12.2	5	17.8	—5.6
19	17.8	18	15.0	+2.8
Average	16.2		15.2	+1.0

As to the general effect of the fertilizer plats as against those unfertilized there is shown an increase of 3 bushels per acre.

A TRIAL OF SUPERPHOSPHATE UPON GRAIN.

In addition to the regular fertilizer trials on the University Farm, a series of co-operative trials with superphosphate were conducted by a number of growers during the season of 1909-10. In these trials both the seed and fertilizer were drilled at the same time with a Superior Combined Fertilizer and Grain Drill. A study of the table will show that no profitable results were obtained in any of the trials with superphosphate alone, except in the case of the Experiment No. 3 at Corcoran. This should not be taken, however, as demonstrating that superphosphate should not be used for grain, as it represents but one season's work. The data are only valuable as supplementing other work, and are published only as a matter of record of work. The results of these tests are shown in tabulated form below:

TABLE VI.—SHOWING CO-OPERATIVE TRIALS OF SUPERPHOSPHATE UPON GRAIN CROPS, SEASON OF 1909-10.

No. of Experimenter	Locality	Kind of Grain	Rate of seeding Lbs. per acre	Date of seeding	Character of Soil	Area seeded: acres Fertilized	Area seeded: acres Unfertilized	Yield per acre Fertilized	Yield per acre Check	Lbs. Gain or Loss
(1)	Erle	Tex. Red oats	65	Nov. 29-Dec. 23	Light clay	49.70	47.75	1063	989	+ 74
(2)	Davis	Chul wheat	100	Feb. 2-14		25.50	25.70	1123	986	+134
(3)	Corcoran	Barley	70	Nov. 28-Dec. 15	Sandy loam	18.33	19.81	2351	1930	+421
(4)	Oakdale	.....	.....	.....	.....	.....	.....	.....	.....	.....
(5)	Berlin	Wheat	115	Nov. 18-26	Clay loam	43.80	43.49	1280	1218	+ 68
(6)	Dixon	Wheat	112	Feb. 1-8	Clay loam	21.60	21.61	2387	2426	— 39
(7)	Oakdale	Wheat	90	Dec. 15-24	Sandy loam changing to adobe	20.9	10.2	608	629	— 19
(8)	Newman	.....	.....	.....	.....	.....	.....	.....	.....	.....
(9)	Montpelier	Barley	75	Jan. 27-Feb. 2	.....	27.7	77.7	521	412	+ 9
(10)	Livingston	Oats	90	Jan. 12-20	Sandy loam	27.55	28.32	457	544	— 97
(11)	Hollister	Wheat	60	Jan. 11-31	Heavy clay	46.25	31.50	715	693	+ 22
(12)	Madera	Barley	62	Jan. 31-Feb. 2	Clay loam	Failure from lack of moisture				
(13)	Davis	Barley	100	Feb. 20-Mar. 1	Clay loam	35.45	34.81	2030	2019	+ 11

DRILL VS. BROADCAST SEEDING.

Fully 90 per cent. of California grain growers still broadcast their grain notwithstanding drilling of seed has been shown to be much more effective. In order to demonstrate this under our own conditions, twenty-two comparative trials have been made, other conditions being the same, and the results are tabulated below:

Fig. 14.—Drilling wheat at University Farm, Davis.
(See Table IX.)

TABLE IX.—RELATIVE RESULTS FROM DRILLED VS. BROADCAST SEEDING UPON THE YIELD OF GRAIN.

AVERAGE OF 22 TRIALS.

	Barley	Wheat
Drilled	70.80	34.85
Broadcast	64.43	31.60
	6.37 bu.	3.25 bu.
Percentage increase	9.9	10.3
Money value	$3.18	$3.12

It pays to drill instead of broadcast seed.

TIME OF SEEDING.

It is of course impossible to give any fixed date at which seeding should be done because of so widely varying climatic conditions, and the impossibility of seeding a large acreage within a few days. Generally speaking, however, *early seeding should be encouraged for the securing of a high yield.* The quality of wheat produced on early seeded areas, however, will be somewhat lower than upon those late seeded. A great many analyses of early seeded (before December 20th) wheat as compared with late seeded (after January 25th) have conclusively shown that the former tends to produce a grain large in size, heavier in weight, lighter in color, a larger yield, and distinctly lower in gluten.

TABLE X.—RESULTS OF EARLY VS. LATE SEEDING OF GRAIN.

	1907-10 Wheat: 63 trials	1910 Wheat: 18 trials	Barley: 13 trials
Early seeding (before Dec. 20)	44.39 bu.	45.01* bu.	63.79 bu.
Late seeding (after Jan. 25)	40.32	42.05	48.90
In favor of early seeding	4.09	2.96	14.89
Percentage increase	10.14	7.04	30.5
Increased money value	$3.93	$2.84	$8.93

Wheat figured at $1.60 per cental; barley at $1 per cental.

* Seeded Dec. 20-25.

THE SELECTION AND TREATMENT OF SEED.

There would seem to be little necessity of discussing the importance of good seed, yet that comparatively little attention is given to this matter of seed selection is certainly indicated by the samples of seed-wheat which have been collected from farmers by the writer. Further, it is highly prejudicial to the highest results that there are numerous erroneous ideas, held very tenaciously, as to several points concerning seed-wheat. There is little doubt that much of the present condition of low yield is due to the lack of attention to the rational selection of first-class seed—*the best of seed is always the cheapest.*

It is certain that one of the factors which has tended to reduce the yield of wheat in California is the egregious blunder of constantly selecting small and shrunken grains for seed. If there is one thing that has been conclusively demonstrated by the most carefully conducted experiments, it has been the superiority of product, in both quantity and quality, obtained from the selection of large, vigorous heavy grains for seed. Numerous experiments, conducted both in

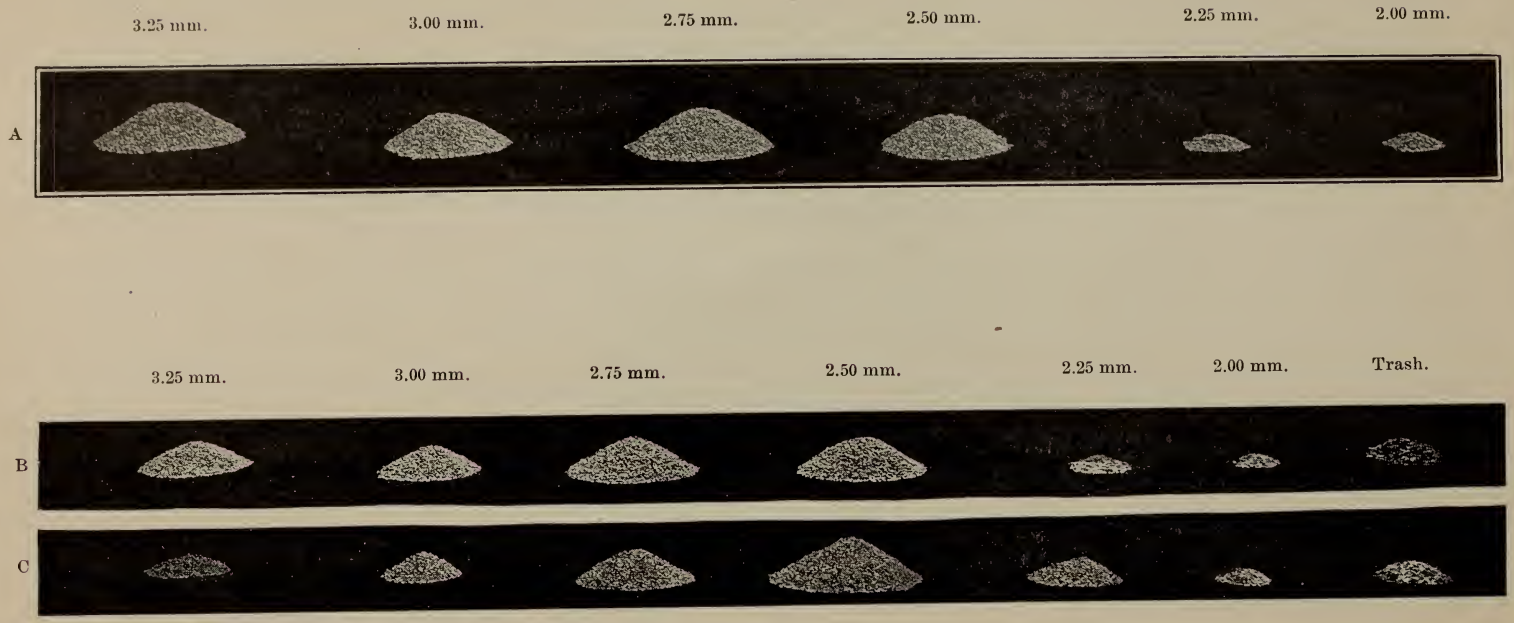

Fig. 15.—Comparing the average grading of (A) a standard sample of White Australian with (B) the best 25 per cent. of White Australian samples and (C) the average of all samples of the same variety.

this country and in Australia, not only with wheat, but also with corn and other grains, have so conclusively demonstrated this point as to render it beyond question, yet we find growers continually selecting the poorest of parental seed, thus gaining a constantly degenerating product, both as to quantity and quality. The sole idea seems to be to get the largest number of plants upon an acre of ground, irrespective of the fact that quality of grain as well as quantity makes for profit.

An attempt has been made during these investigations to gain a knowledge of the general character of seed being used by wheat growers. To this end, many samples of the common wheats about to be used for seed were secured from growers and sieve-graded upon an arbitrary basis for comparison against a typical lot of the same variety of wheat.

The samples collected for examination were obtained over a wide area in the Sacramento and San Joaquin valleys, the two great wheat-growing sections of the State, and probably fairly represent the general character of the seed used by the farmers of the State. The separations made are set forth below in tabular form, and when examined show a number of things of interest bearing upon the matter of the character of seed-wheat being used by the farmers of the State.

The figures are the results obtained by separating the several sizes of grains by means of a set of sieves with meshes of arbitrary size.

The results of such grading are shown in Fig. 14 and the following table:

TABLE VII.—COMPARING THE GRADING OF GOOD AND POOR SEED.

	1 3.25 mm. %	2 3.00 mm. %	3 2.75 mm. %	4 2.50 mm. %	5 2.25 mm. %	6 2.00 mm. %	7 Trash. %	Weight per bu. Lbs.
Standard	28.61	18.49	28.74	19.62	1.83	1.93	.75	60.5
Average of 25% of best samples	17.58	14.24	30.31	28.46	2.46	1.29	5.89	58.2
Average	6.56	8.23	22.16	47.20	9.74	2.19	3.84	57.7

From this it may be seen that there is room for much improvement in the grade of our wheat, even though no higher standard be taken than that used by the best one-fourth of the growers here represented; and if we should exclude from the average the best one-fourth the difference would be still more striking.

From the standpoint of practical work it may be argued that it is impossible to secure as high a grade as here represented by the standard, but it is certainly fair to assume that all can easily secure a seed which will grade as high as the average used by 25 per cent.

of the growers here represented. Special attention is called to this because it is a standard entirely possible for the wheat-growers to reach, and there is little doubt that the wheat crops would be much improved by such seed, and it is a plan that could be put into immediate operation. It is the worst kind of folly to continue to plant small, light seed when it is so easy to secure seed of good, if not of the very best, quality. No grower, however, should be satisfied with anything short of *the best* for seed, and by so much as he lowers his standard in this respect does he multiply his chances of failure. This is the more important since the climatic conditions which obtain in the wheat-growing sections of the State are decidedly fickle, particularly as to moisture and those conditions which lead to rust attacks. We should take every precaution to secure the best of seed—large, plump, and vigorous—but should remember that by far the better results can be obtained if we are also certain that the seed has come by selection from strong and vigorous plants.

SELECT SEED FROM PRODUCTIVE PLANTS.

In connection herewith it should be stated that the highest results can only be obtained when the seed is selected from productive individual plants, and that under favorable conditions even small perfect seeds from productive plants may be better than large seeds from unproductive plants. The main influence of large grains selected by simple sieve grading will be in giving the plants a more vigorous start in life, which of itself is of extreme importance. Other things being equal, it is entirely fair to presume that the crops which are placed under the most favorable environment are going to give the best returns. It has been shown that, in general, the more vigorous plants (that is, those having the largest spikelets) contain the larger grains, so that even in selecting the grains by simple sieve separation the bulk of the larger grains would come from the more vigorous plants, and thus there would be, in a measure at least, a selection from vigorous plants.

LARGE AND PLUMP VS. SMALL AND SHRIVELED SEED.

A condition much to be deplored is the great tendency of growers to use small, pinched seed. It is not easy to give an accurate definition as to what is meant by shriveled seed, but Fig. 16 will serve to show the contrast between plump and shriveled seed as here discussed. Doubtless the entire discussion is due to the fact that extremely inferior looking seed will actually germinate and to a certain extent

grow and bear a crop, and *under favorable* conditions may even produce a good yield. This fact has unfortunately given rise to much

A

B

Fig. 16.—Showing the difference in the vigor of germination between (A) plump and (B) pinched seed-wheat.

carelessness in the selection of seed-wheat, which must be overcome if we are to secure the highest results in grain culture.

The main reason for the superiority of large, heavy grain for seed purposes is physiological, and lies in the larger reserve food supply in the larger seed. It has been shown that heavier seeds possess more

of the important plant foods (phosphoric acid, nitrogen, and potash).[1] These materials are the first nourishment which the plantlet gets; there is abundant material immediately available to the plantlet, and the young plant is soon in a position to take a vigorous hold upon the soil.

That the germination of such pinched seed is fair is indicated by a germination test which showed 92 per cent. of the grain actually germinated, but the plantlets were very weak, and undoubtedly their vitality would always remain low. (See Fig. 16.)

These results are in entire harmony with what we know as to the necessity of securing vigorous, plump seed in the case of alfalfa and other crops. The same fact is recognized by the farmer with reference to the parentage of his animals, but unfortunately the idea holds that the case is different with wheat.

CLEAN AND GRADE SEED WHEAT.

Small and pinched kernels, as well as weed seed, should be removed from grain that is to be used for seed purposes. There is no better investment for a grain grower than the purchase of a seed cleaner and grader. There are numerous good machines for this purpose on the market, among which may be mentioned the Owens Advance cleaner and grader, the Chatham Mill, and the Globe Separator and Grader; all of which we have had in use upon the Stations.

EFFECT OF CHANGE OF SEED.

There is a very widespread belief among grain-growers that there is a necessity for frequent change of seed because of actual deterioration due to continued culture under the same soil conditions. This idea is held to such an extent as to be well nigh universal. Yet, the most carefully conducted investigations, with scarcely a single exception, go to show that not only is there no benefit to be derived from the *mere change of seed,* but that actual loss occurs. In the light of these carefully conducted experiments we may safely lay down the principle that *unless the change be for the purpose of obtaining a better variety or a stronger seed* there can be no advantage resulting from a change of seed-wheat, and in case seed be purchased from a portion of the country where climatic conditions are quite unlike those of California the seed is not likely to be at its best for several years.

If seed shows signs of "running-out" it simply means that proper care has not been taken in the selection of the seed to remove small,

[1] A further discussion of the seed question may be found in Bulletin No. 181 of this Station.

shriveled, and light-weight kernels, and to use only plump kernels. *With proper care in the selection of seed, wheat does not deteriorate from any change within itself.* But to maintain the standard of yield *care must be taken in the selection of the best seed* and to practice rational methods of rotation, manuring, and tillage to maintain the fertility of the soil.

PREVENTION OF SMUT.

The grain smuts in California cause an annual loss in the crop of the State that may be conservatively estimated at over $1,000,000. Not only does this direct loss occur, but there is a further loss through a lowering of the commercial grades, which is occasioned by the presence of even a small quantity of smut on the grain. Farmers, doubtless, do not realize the large loss which occurs annually from this trouble. Its widespread occurrence in the State is the more to be deplored since the preventive methods which can be employed are both easy of application and extremely effective.

The smuts of grain are caused by the growth of minute parasitic plants that live within the tissues of the grain plants and are nourished by their juices.

While there are certain minor ways in which the disease may infect a field, the major amount of the infection in every case enters by way of the seed; therefore, the greatest care should be taken to so select, care for, and treat the seed as to prevent sowing living smut spores with the seed grain.

While there are two quite distinct classes of the so-called smuts which affect grain crops, one known as loose, or black smut, and the other stinking smut, or bunt, of wheat, it is the latter which causes by far the greatest loss in wheat.

On account of the fact that the spores may remain entirely inclosed in the wheat grain, and of the very disagreeable odor, it not only is capable of seriously reducing the yield, but also damages the quality of the associated sound grain when milled, by imparting a disagreeable odor to the flour.

METHODS FOR SMUT PREVENTION.

Since the major source of infection is through the medium of the seed, it is necessary that all seed sown be treated by such a process as will kill the smut spores adhering to the grain without injury to the latter. There are two methods which can be recommended as well nigh positive in result, when the seed has been properly treated.

These methods are set forth below in the order in which they are recommended.

Formalin Method.—Use one pound of formalin (a 40 per cent. solution of formaldehyd) to 50 gallons of water. The solution may be placed in barrels or tanks until used. The wheat may be dipped into the solution in loosely woven bags or wire baskets, allowed to remain for ten minutes, and then drained to save all the liquid possible, and dried, when it is ready to sow.

If it is preferred, the seed may be spread on a clean canvas or board floor and the formaldehyd solution applied with a sprinkler, or hose and nozzle, constantly stirring and mixing the grain with a rake or shovel until all the kernels are thoroughly wetted, when it is allowed to dry.

Be sure to get 40 per cent. formalin. Dealers sometimes give a 25 or 30 per cent. formalin for a 40 per cent.

The formalin should be weighed in order to make sure that a full pound to each 50 gallons of water be used. The cans in which the formalin comes often contain only three-fourths of a pound, hence the necessity of this precaution.

This treatment has an advantage over some others, in that it is not poisonous to persons handling the material.

A Machine for Treating Wheat to Prevent Smut.—Of late there has come on to the market a machine for the formaldehyd treatment to prevent smut. It is a very efficient arrangement for this purpose since it insures the thorough wetting of each kernel and at the same

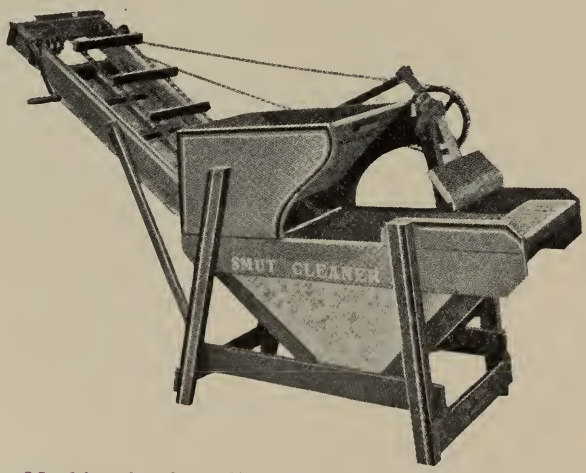

Fig. 17.—Machine for formalin treatment to prevent smut on grain.

time removes by means of a scraper wild oats, light seeds, and unbroken smut balls. An illustration of this machine is shown in Fig. 17. The seed is poured into the hopper and fed into the formaldehyd solution contained in the tank below. It passes loosely through this solution and is conveyed by the elevator to a fresh sack or box. The skimmer is one of the most important parts of the machine, for it removes from the surface of the solution all the unbroken smut balls, wild oats, and light trash which float on top.

In treating oats the action of the skimmer is reversed so the grain is forced in front of the return carriers, and by them into the bottom of the treating tank, then elevated as wheat.

Bluestone, or Copper Sulfate, Method.—This is the method practiced almost exclusively in California. Its lack of effectiveness in many cases may generally be traced to a lack of thoroughness in the work, or to re-inocculation of the seed in some manner after treatment.

A solution is made by dissolving 1 pound of blue vitriol in 4 gallons of cold water, and dipping the wheat in the solution, as above, until the grain has become thoroughly wetted, after which it is immediately dried. Or the wheat may be piled upon a floor or canvas, and thoroughly sprinkled or sprayed with the solution while the grain is being constantly shoveled over so that every grain becomes wet over the entire surface. Care should be taken that the solution is of uniform density by thoroughly agitating just previous to use.

EFFECTIVENESS OF TREATMENTS FOR SMUT PREVENTION.

To ascertain the relative effectiveness of several methods of treatment and more particularly to test the effectiveness of dilute sulfuric acid for the prevention of stinking smut, in the season of 1909 comparative trials were made of the well recognized fungicides, bluestone, and formaldehyd, also a proprietary preparation known as Anti-fungi, and two different dilutions of sulfuric acid.

In this trial five varieties of wheat were employed and one of barley. About three pounds of smut-free seed of each variety were thoroughly infected with stinking smut by shaking the seed with a quantity of the powdered smut balls. The solutions were made up according to the strengths indicated in the tabular statement subjoined, and a separate portion of each lot of wheat immersed in each of the solutions, one portion being reserved for planting untreated to serve as a check. The results are tabulated below:

TABLE VIII.—RESULTS OF TREATMENT TO PREVENT SMUT IN GRAIN, 1909.

CLEAN SEED INOCCULATED WITH SMUT SPORES.

	Per cent. smutted plants at harvest					
Name	Untreated	Bluestone 1 lb to 4 gals.	Antifungi 1 lb. to 2½ gals.	H_2SO_4 1-1000 by wt.	H_2SO_4 1-500 by wt.	Formalin 1 lb to 50 gals.
White Australian	75.2	0.19	1.23	60.66	16.47	29.07
King's Early	62.4	1.30	1.15	59.25	58.54	13.50
Chul	48.8	0.00	2.36	59.91	19.32	28.62
Velvet Don	45.5	0.00	0.17	49.92	5.30	16.80
Sonora	16.7	0.18	0.00	52.74	0.32	0.00
Average	49.7	0.33	0.98	56.49	19.99	17.29
BARLEY.						
Common California	56.3	0.00	0.00	11.00	0.58	0.00

It will be noted that while practically 50 per cent. of the grain from the untreated seed was destroyed by smut, only one-third of 1 per cent. of the "bluestoned" seed was lost. This shows the well recognized effectiveness of this treatment. The "Anti-fungi" treatment was very effective, the loss in this case being a trifle less than 1 per cent.

Sprayed. Unsprayed.

Fig. 18.—Showing effect of spraying with iron sulfate to kill mustard.

The 1-1000 sulfuric acid solution was far too weak to be of value, but the stronger acid solution (1 to 500) was nearly as effective as the formalin and is probably worth further trial.

It is further quite evident that certain varieties of wheat are much more smut-resistant than others, and that White Australian is very susceptible to the fungus.

SPRAYING TO KILL WEEDS.

In 1905-06 some experiments were made to test the effect of spraying the plats at Yuba City with a solution of copper sulfate to kill the wild radish. The results were not very satisfactory as a whole. In many of the plats the weeds were so large that even one hundred gallons per acre of the solution would not cover the weeds sufficiently to kill them. In cases where very small plants were

Fig. 19.—Showing effect of spraying with iron sulfate to kill mustard.

sprayed the weeds were killed, but the land was so infested with seed that every shower caused more plants to grow. A solution of one pound of copper sulfate to two gallons of water and applied at the rate of about one hundred gallons per acre proved effective in killing young plants of the mustard and radish, besides various other weeds, without resulting in permanent injury to any of the cereals. In some cases the upper portion of the blades turned brown at first, but growth was not retarded materially, and in a week or ten days the plants had resumed their usual green color. Experiments in spraying to kill weeds in grain fields were taken up again in 1908-09. In these trials iron sulfate was used instead of copper sulfate and with more effective and more economical results. The details of the several trials made will not be set forth at this time, but suffice it to say that the trials showed the effectiveness of this treatment for the killing of mustard, but it did not prove effective for killing radish. In these trials the iron sulfate was used at the rate of 140 pounds per acre. In general, it may be said that about 65 per cent. of the mustard was killed by one application of this spray. However, the present freight rates upon this iron sulfate renders it prohibitive to use the material on a large scale, as much as it is needed in some sections of the state.

CHARACTERISTICS OF WHEATS DESIRABLE FOR CALIFORNIA.

Considered only in relation to field conditions there are certain special characteristics which are extremely desirable for wheats which are to be introduced into this State. The following are considered the most prominent of these: manner of growth, tenacity, days to mature, character of head (especially with respect to awns), rust resistance, and heavy yielding plants.

In the selection of a variety, climatic, and soil conditions must be given consideration, for certain varieties are more suitable for light soils than for heavy soils, and vice versa. Further, some varieties are much more able to withstand drought than others. This latter condition is of special significance under "dry farming" conditions. Further, there is considerable difference in the ability of varieties to withstand attacks of rust, which, in the coastal regions, is a factor of much importance; in the interior section, however, this is of less consequence.

EARLY MATURITY.

Earliness, as measured by days to mature, is an important point for consideration in the selection of grains for use in California. The wheats should be such as can be planted as late as possible and will have a rapid growth and mature early, before the exceedingly hot weather comes on in the summer. Further, earliness is a great factor in enabling the wheats, and grains in general, to withstand rust attacks, which are very severe in certain sections. This is extremely important for wheats grown in the coast counties, for in that region rust is an omnipresent difficulty, owing to the more moist atmosphere. Further, the early wheats are not as apt to be injured by drought as the later maturing varieties.

HABIT OF GROWTH.

The manner of autumn growth (that is, whether the growth is upright or spreading) is of unusual importance under the present condition of the grain fields as to weeds. Until the farms are in a much cleaner condition than at the present time no wheat is likely to meet with favor unless it will make a reasonably good fight for life among weeds. This factor is not so important in the case of wheats used on summer-fallow land, but in many instances even in this case, it is of some importance, because the continued use of the combined harvester, coupled with generally careless methods, have so seriously scattered the weeds in the grain fields as to make even the summer-fallow land exceedingly foul. In such fields the plants that have a low-spreading growth in the fall and winter have but little chance against the weeds. It is the strong upright growth made by the varieties commonly grown in the State that has been one of the main factors which has enabled them to hold their own in the State despite their low milling qualities. This rapid upright growth enables them to successfully keep ahead of the weeds and finally win in the race. With the farms becoming smaller and being given greater care, and the introduction of the binder, this factor possibly will not be as important. Generally speaking, however, these same spreading varieties require early planting, and for this reason under the conditions of precipitation which hold in large grain-growing sections of the State it is difficult to get them planted, except on summer-fallow land, sufficiently early to have them under favorable conditions for good yield. They must be growing by December 1st to be under even fair conditions, and it is seldom, indeed, except

on summer-fallow land, that it would be possible to seed by that date. This will be one of the greatest obstacles in the introduction of these wheats into this State. *Our present idea is that varieties whose early growth is of a spreading character are not well suited to the climatic and other conditions which obtain in this State generally,* unless it be in those parts of the State where limited areas of wheat are grown

Seeded Dec. 6. Seeded Jan. 15.

Fig. 20.—Showing necessity of early planting for spreading winter wheats. Both plats same variety of wheat. Photographed May 1st.

by irrigation, where a late summer or early fall irrigation can be given the land, thus enabling it to be put into condition earlier than otherwise would be possible. Such varieties may, however, be suited to the smaller valleys in the mountain sections of the State.

TENACITY, OR NON-SHATTERING HABIT.

The tenacity with which the chaff holds the grain is also an especially important factor in California, where the combined harvester is so extensively used. Grain frequently stands in the field

for a month to six weeks after it is mature, and under the heavy winds which prevail in the Sacramento Valley, and certain parts of the San Joaquin Valley, unless the chaff is very tenacious of the berry there is serious loss. With the use of the self-binder instead

Fig. 21.—Showing typical heads of different classes of wheats, one-half natural size. A, beardless common wheat, White Australian; B, bearded common wheat, Turkey Red, a spreading winter wheat; C, bearded durum wheat, Kubanka.

of the combined harvester this loses something of its significance, but it will always be a factor of importance. The wheats which have survived in the struggle for existence here have been of this character, and it is one of the principal points in which the Little Club variety appeals to the farmer, and out-weighs the undesirable points of this wheat.

CHARACTER OF HEAD.

The character of the head as to awns is of greater importance than in most places, because it is a custom here, and one which the fickleness of the climate renders almost necessary, for farmers to be governed largely by the character of the season as to whether the crop is allowed to mature its grain or whether it is cut for hay. If the season seems to be unpropitious for the maturing of a fair crop of grain it will be cut before maturity for hay. Thus, an awnless variety is much preferable.

MILLING QUALITY.

Perhaps no factor in the selection of a variety is of greater importance in California than that of the milling quality. Practically no flour is made today anywhere from wheats milled of one variety alone. Practically all flour is the result of a blend of varieties. On account of the low gluten content of the type commonly grown in California an undue quantity of wheat has to be imported from Kansas and other points to build up the gluten content of the manufactured flour to a sufficient quantity and quality. It is highly desirable to find and introduce varieties that will lessen these importations. The milling value of a wheat is judged by both the quantity and quality of the flour product. The quality of the flour for baking is determined by its gluten quantity and quality, and its color. It is highly essential that varieties be grown which will produce more and better gluten per acre.

OTHER REQUISITES.

The importance of high yielding plants is too evident to need any discussion. No other characteristic of a plant is so important, and most of those mentioned above have a bearing upon this quality.

The possession of a stiff or weak stem, and resistance to bunt, are all factors that should be considered by the grower.

SEED IMPROVEMENT BY THE GROWER.

The farmer can do much toward the improvement of his own seed by attempting to bring it to a high standard of perfection and purity of variety by proper methods of selection and culture, which is far preferable to the constant and indiscriminate change of seed practiced by so many. It has long been the practice of farmers to make a sort of selection of seed corn, and to some extent of seed potatoes, but the fact that seed grain is as capable of improvement by such selection

seems to have been well nigh overlooked. The practice of indiscriminate seed exchange precludes the possibility of any permanent crop improvement by careful culture and seed selection. While the farmer can not follow out the details of plant breeding, yet it is entirely feasible for him to practice with his own crops straight selection of seed.

Fig. 22.—Seed selection plats, University Farm, Davis.

MAINTAIN A SEED PLAT.

The maintenance of a seed plat for the improvement of seed should be the practice of every grain grower in California. This plat should be located at different parts of the farm every two or three years. The location should always be where the soil is of uniform quality, but one should avoid areas of special fertility. It is important that the seed plat should be located on *clean* land, and particular care should be taken that the land be free from other varieties of grain. It is best, then, that the land should have been under clean culture the preceding year, or that some cultivated crop should have been grown in the preceding year. Just before harvest go through a field of a good, hardy, standard variety that has given the best results in the locality and mark plants that exhibit to the highest degree the

special quality which it is desired to increase, such as freedom from rust, fertility of head, or otherwise, and which are at the same time at least as good as the average in other respects. At harvest time cut with a sickle enough of these marked plants for sowing the plat, and, after threshing them, select the largest and most vigorous seed for this purpose by means of a screen, or, preferably, gravity grader. Sow the plat early, drilling it at the average rate of about 80 pounds per acre. From this seed plat select as above seed sufficient to reseed a similar plat the following season, and harvest and thresh the remainder of the crop from the seed plat separately from the main crop, care being taken that the machinery used is free from all other grains which might cause a mixture. The first portion threshed should be rejected, as it is most likely to contain such a mixture. The grain from the seed plat should be used, as far as it will go, for the general crop the succeeding year. If there is a considerable acreage it may be necessary to continue the seed plat for a second year in order to obtain sufficient seed for the main crop. In this way seed is never taken from the general crop, which can not be given the same care as the small plat, and there is a constant selection of seed, which is more and more rigid every year. Moreover, there is no extra labor involved, except the small amount required for seed selection each year.

VARIETY TESTS.

A large number of variety tests of wheat have been conducted by the University during the past five years, but very few of them have shown characteristics thoroughly adapted to California conditions. The variety tests have not yet been conducted for a sufficient time to enable a positive statement to be made as to the adaptability of all of these varieties in any particular locality. There is probably *no one best variety* even for one section. Varieties which produce good yields in one section are found to give poor returns in other section. Some varieties do better on heavy soil, others on light soil. *Further work needs to be done concerning a wider variety of conditions.* However, the work already done indicates that there are a number of varieties that will probably meet the prevailing conditions better than the commonly grown wheats.

In the following tables the results of variety tests are shown. The wheats are classified as the spreading winter types, the upright spring types, the durum types, and the hybrids which have shown promise.

TABLE XI.—SHOWING AVERAGE YIELD OF WHEATS OF THE SPREADING TYPE AT MODESTO AND CERES, 1907-10.

C. I. No.	Variety	Av. number of days maturing	Av. number days in fruiting period	Non-shattering character	Av. yield per acre—Variety	Av. yield per acre—Check
2210	Cap Sheaf	168	38	Fair	24.7	48.4
1437	Crimean	176	35	Fair	26.5	31.8
2988	Dietz Amber	167	37	Fair	15.7	22.1
2398	Galgalos	168	37	Good	32.3	34.3
1442	Kharkov	170	29	Fair	30.1	32.3
2989	Jones' Fife	178	36	Fair	23.1	26.0
2873	Glyndon	178	35	Fair	18.1	26.0
1561	Theiss	176	36	Fair	19.8	28.9
	Rice	165	.....		19.7	48.4
1558	Turkey	173	39	Fair	32.1	30.3
	Gold Coin	172	33	Fair	15.3	29.3
2592	(Unnamed)	180	40	Fair	41.0	41.2

Generally speaking, the wheats of spreading type have not equalled the upright growing varieties, and they are not well adapted to the conditions in the large wheat growing areas of the State, although they may be adapted to some of the smaller valleys in the northern part of the State.

The United States Department of Agriculture hybrids, and also those from Kansas, are practically all of this type. Some of these have made excellent showing in the matter of yield, but they deteriorate in quality quite easily. It is very doubtful whether they can ever be made highly desirable wheats for California. A tabulation of the results with the hybrids of this type is shown below:

TABLE XII.—TABLE SHOWING AVERAGE YIELD OF HYBRID WHEATS, 1908-09.

Hybrid Number and Cross	Av. number of days maturing	Av. number days in fruiting period	Non-shattering character	Average yield
1406 x Mediterranean, 31a7-1-1-1-1-1-1-1..	168	40	Fair	37.7
1406 x Mediterranean, 31a9-1-1-1-1-1-1-1..	168	39	Poor	59.9
1406 x 1405, 32a4-1-1-1-1-1-1-1	168	39	Fair	38.7
Dawson's Golden Chaff x Jones' Winter Fife, 35a2-1-1-1-1-1-1-1	168	40	Fair	47.1
Turkey x Extra Early Oakley, 350a4-1-1-1-1-1-1-1	168	40	Poor	40.9
Turkey x Extra Early Oakley, 350a5-1-1-1-1-1-1-1	168	40	Poor	39.7
Turkey x Extra Early Oakley, 350a6-1-1-1-1-1-1-1	168	40	Poor	46.1
Red Winter Fife x (Onigara x 1344), 351a2-1-1-1-1-1-1-1	168	36	Fair	48.7

Hybrid Number and Cross	Av. number of days maturing	Av. number days in fruiting period	Non-shattering character	Average yield
Sea Island x (Yemide x Dawson's Golden Chaff), 362a3-1-1-1-1-1-1-1	170	37	Fair	46.5
Sea Island x (Yemide x Dawson's Golden Chaff), 362a4-1-1-1-1-1-1-1	170	37	Poor	43.8
Sea Island x Polish 366a-1-1-1-1-1-1-1	170	37	Fair	50.2
Currel x Banat, 1803-2	171	37	Poor	44.7*
Andrew's No. 4 x Zimmerman, 1806-2	171	37	Very poor	34.7*
Weissenberg x Currel, 1807-1	171	37	Fair	42.7*
Red May x Banat, 1808-1	164	32	Fair	49.0*
Penquite's V. C. x Zimmerman, 1823-1	175	40	Fair	30.0*
German Emperor x Turkey, 1832-2	175	41	Fair	23.3*†
Penquite's V. C. x Zimmerman, 1833-3	171	37	Fair	10.7*†
Dawson's Golden Chaff x Turkey, 1850-2	175	41	Fair	5.3*†
Banat x Turkey, 1860	175	39	Fair	3.3*†

* One year only (1909).

† Soil very light and poor.

The following table (XIII) shows the characteristics and average yields of wheats of the erect growing type, together with the average yield of the check plats of White Australian grown under the same conditions at Modesto and Ceres:

TABLE XIII.—SHOWING THE AVERAGE YIELD OF WHEATS OF THE ERECT GROWING TYPE AT MODESTO AND CERES, 1907-10.

C. I. No.	Variety	Av. number of days maturing	Av. number days in fruiting period	Non-shattering character	Av. yield per acre—Variety	Av. yield per acre—Check
1698	Allora	161	45	Good	38.1	41.1
3019	White Australian	169	38	Fair	32.6	.....
2511-2	Blenoir	155	39	Fair	48.1	48.7
2921	Bolo Blanco	169	46	Good	51.4	41.8
2986	California Gem	165	38	Fair	29.1	32.6
2227	Chul	166	41	Excellent	41.7	34.7
3018	Club	158	41	Good	29.9	30.5
2397	Erivan	169	35	Good	40.6	36.1
1697	Early Baart	159	38	Fair	24.6	22.8
1596	Fretes	169	42	Fair	46.5	36.6
2888	Filippino	172	38	Very good	30.9	35.9
1970	Propo	164	42	Fair	37.3	33.2
2991	Purple Straw	161	35	Fair	45.0	49.8
2984	Saumaur de Mars	172	37	Poor	38.9	37.6
2983	Chiddam	172	38	Poor	38.4	37.6
2899	Chul (selection)	139	36	Very good	33.3	29.9
1743	Sonora	158	44	Fair	34.8	35.2
2985	W. Bluestem	176	36	Fair	21.8	30.3
	Bobs	145	43	Fair	45.4	40.3

DURUM WHEATS.

The durum types of wheat have proven to be quite erratic producers both in quantity and quality of product. All the durum varieties have an upright growth. The performance of a number of the more promising ones at Ceres is shown in the tabulation below:

TABLE XIV.—SHOWING AVERAGE YIELD OF DURUM WHEATS, 1908-09.

C. I. No.	Variety	Av. number of days maturing	Av. number days in fruiting period	Non-shattering character	Yield per acre: bu. 1908	1909	Average
1593	Marouani	164	41	Good	12.8	36.8	24.8
2235-2	Marouani	162.5	39.5	Fair	46.7	33.3	40.0
2096	Yel. Gharnovka	164	40	Good	31.8	18.0	24.9
2221	Kubanka	164	40	Good	26.8	26.5	26.6
2246	Kubanka	164	39.5	Good	30.8	21.8	26.3
2247	Velvet Don	164	39.5	Good	32.8	14.2	23.5
2537	Marchand	167.5	40	Fair	32.6	14.0	23.3
2545	Semonlier	167.5	40	Fair	41.6	18.0	29.8
2547-2	(Unknown)	167.5	40	Fair	52.9	18.7	35.8

Fig. 23.—White Australian wheat, 1908, at University Farm, Davis.

TABLE XV.—SHOWING YIELD OF WHEATS AT TULARE STATION, 1907-09.

Cal. No.	Variety	Manner of early growth	Av. number of days maturing	Av. number days in fruiting period	Non-shattering character	Yields at Tulare: bu. per acre 1907	1908	1909	Av. 3 yrs.
1003	Dawson's Golden Chaff	Spreading	177	44	Fair	35.3	32.0	31.0	32.7
989	Fultz*	Spreading	172	41	Fair	34.3	48.6	18.6	33.8
993	Crimean	Spreading	176	45	Fair	35.3	47.2	28.0	36.8
994	Pesterboden	Spreading	179	41	Fair	28.0	56.0	31.4	38.5
991	Beloglina	Spreading	180	43	Fair	34.0	38.6	30.3	34.3
992	Kharkov	Spreading	183	45	Fair	12.6	44.6	20.0	25.7
990	Theiss	Spreading	172	46	Fair	42.0	56.0	31.0	43.0
1002	Gennesee Giant	Spreading	169	40	Fair	22.1	30.0	18.6	23.6
1001	Clawson's Longberry	Erect	171	27.5?	Fair	20.7	35.6	15.2	25.5
1004	Allora	Erect	155	46	Good	30.6	47.1	22.3	33.3
1000	King's Early	Erect	157	46	Fair	32.4	52.6	22.1	35.7
1005	Fretes	Erect	160	49	Fair	.....	58.3	28.9	43.4
988	Fultz†	Erect	179	45	Fair	35.9	52.0	38.6	42.2
907	(Unknown)	Erect	.....	....	Good	50.4	65.3	26.9	47.5
480	Propo	Erect	169	39	Fair	44.6	45.0	36.0	41.8
459	Little Club	Erect	160	40	Good	30.7	51.3	20.0	34.0
466	California Gem	Semi-erect	169	41	Fair	42.5	45.7	10.3	32.7
483	Thibet	Erect	145	43		.....	32.0	13.3	22.6
1009	Galgalos	Spreading	160	40	Good	.....	38.6	26.6	32.6
998	Chilean	Erect	147	44	Good	52.3	46.6	35.0	44.6
1008	Glyndon	Spreading	170	39	Fair	.....	32.0	32.0	32.0
1010	Saumaur de Mars	Erect	.....	....		.....	30.0	22.6	26.3
1007	Capetown	Erect	161	40	Fair	.....	57.2	29.3	43.6
996	Black Don	Erect	165	45	Good	29.0	38.0	29.3	33.6
995	Kubanka	Erect	147	45	Good	22.0	42.6	33.0	37.8
997	Kahla	Erect	178	42	Good	.....	36.9	42.8	39.8
954	Early Baart	Erect	165	52	Fair	.....	47.2	32.0	39.6
481	Sonora	Erect	156	47	Fair	.....	59.0	27.5	43.2
1011	Chul	Erect	163	45	Excellent	.....	29.0	33.3	31.3
107	Vol Korn		.....	....		.....	.....	29.0	29.0
820	Bolo Blanco	Erect	139	40	Good	.....	.....	54.0	54.0
452	White Australian	Erect	168	44	Fair	30.0	44.2	25.4	33.2

* Beardless.
† Bearded.

TABLE XVI.—SHOWING AVERAGE YIELD OF WHEATS OF THE ERECT-GROWING TYPE AT DAVIS, 1907-10.

		Av. yield per acre, bushels — Seeded before Dec. 20th		Seeded after Dec. 20th		Grand average		Average per cent. of Check yields
		Variety	Check	Variety	Check	Variety	Check	
2397	Erivan	46.6	60.2	38.6	49.6	42.6	54.9	77.6
1698	Allora	33.8	55.2	13.6	45.8	30.3	48.9	61.9
2986	California Gem	43.5	59.2	47.8	58.3	45.8	55.6	82.3
955*	Defiance	38.0	58.0	42.8	56.1	41.6	56.5	73.6
2985	Bluestem	38.3	55.2	54.5	53.8	49.1	54.2	90.6
793*	Japhet	40.3	63.3	41.6	44.4	41.4	47.1	87.9
1596	Fretes	47.3	44.8	35.8	34.5	42.7	40.7	104.9
1746	King's Early	45.7	41.7	38.1	35.0	41.7	38.4	108.6
2899		36.4	42.2	38.8	34.6	37.6	38.4	97.9
779*	Bobs	31.7	42.9	40.6	41.5	35.3	42.4	83.4
1697	Early Baart	49.0	43.8	42.6	39.6	45.8	41.7	109.9
3018	Little Club	55.1	49.3	42.4	42.8	47.5	45.4	107.0
2983	Chiddam	34.3	56.6	39.9	37.5	37.1	47.1	79.0
1970	Propo	48.7	49.3	49.1	47.1	48.9	48.0	101.9
2984	Saumaur de Mars	50.6	58.0	36.3	32.7	39.8	41.5	96.1
2227	Chul	42.4	42.8	35.8	38.3	39.1	40.5	98.9
1743	Sonora	46.2	47.5	45.2	30.5	45.9	41.8	91.2
1131*	Silver King	46.8	50.3	.....	.....	31.2	45.5	68.6
1732	Fishhead	33.7	37.0	43.2	30.5	38.4	33.7	113.8
1132*	White wheat	50.9	48.1	.....	.....	50.9	48.1	105.8
2511-2		48.0	33.2	45.2	36.0	46.6	34.6	134.7
1133*	Cumberland	53.0	38.2	46.2	30.5	49.6	34.3	144.4
2126-2	Kurd	39.0	37.5	41.8	30.5	40.4	34.0	137.0
2200-2	Karun	30.5	37.5	39.2	30.5	34.8	34.0	102.6
2794	Robeiro	47.0	45.1	50.3	28.5	48.0	39.5	124.0
2592	(No name)	36.7	33.2	.....	.....	36.7	33.2	110.5
2074	(No name)	40.3	42.3	.....	.....	.....	.....	95.2
2921	(No name)	35.2	33.2	.....	.....	.....	.....	106.0
2404	(No name)	32.7	33.2	.....	.....	.....	.....	98.5
1593	Marouani	42.9	44.0	49.4	37.6	46.1	40.8	113.1
2235-1	Marouani	46.9	49.5	39.7	36.7	44.5	45.2	98.5
1494	Arnautka	46.6	42.0	21.5	38.7	34.0	40.3	84.1
1595-1	Kahla	51.7	50.1	47.1	36.7	50.1	40.5	123.7
2096-1	Yellow Gharnovka	42.4	43.6	27.2	44.9	31.0	45.6	69.5
2247-1	Velvet Don	51.5	52.0	35.0	43.4	43.5	47.7	90.6
2247-2	Selection	52.3	52.1	37.6	45.0	45.0	48.5	92.7
2089-1	Richi	45.4	46.5	35.3	28.5	42.0	40.5	103.7
1440	Kubanka	46.1	58.9	38.7	36.1	40.5	41.8	96.9
8232	Black Don	45.3	59.6	30.9	48.9	38.1	54.2	70.3
2804	(No name)	53.1	45.3	39.2	28.5	48.4	39.7	122.0
2805	(No name)	47.7	44.6	48.8	28.5	48.0	39.3	122.4
2808	(No name)	60.8	45.3	42.1	29.0	54.5	39.9	137.0
2816	(No name)	57.6	45.3	35.7	29.0	50.3	43.2	116.4
2817	(No name)	71.1	47.0	.....	.....	71.1	47.0	151.1
2797		59.7	47.5	44.5	28.5	54.6	41.1	132.7

* California number.

TABLE SHOWING AVERAGE YIELD OF WHEATS OF SPREADING GROWTH IN SACRAMENTO VALLEY, 1907-10.

C. I. No.	Variety	Av. number of days maturing	Av. number days in fruiting period	Av. yield per acre, bushels — Seeded before Dec. 20th — Variety	Seeded before Dec. 20th — Check	Seeded after Dec. 20th — Variety	Seeded after Dec. 20th — Check	Grand average — Variety	Grand average — Check	Average per cent. of Check yields
1558	Turkey	167	40	32.3	54.0	24.6	44.3	22.3	49.2	45.4
582*	English Master	182	33	24.0	46.7	.....	.....	24.0	46.7	51.1
1438	Ghirka	166	42	37.6	50.9	29.2	39.6	20.9	44.2	47.2
1439	Ultra	161	40	34.6	50.9	14.7	37.8	22.6	43.1	52.5
1923	Fultz	158	41	32.9	50.0	.....	41.5	19.7	45.9	42.9
2873	Glyndon	178	44	40.9	50.4	43.5	50.5	42.0	50.4	83.1
2398	Galgalos	154	47	40.5	37.7	35.6	38.4	37.6	38.2	98.4
1356	Theiss	160	39	17.3	39.3	.....	.....	17.3	39.3	44.0
1437	Crimean	153	38	32.1	39.3	2.7	40.2	21.8	40.8	53.5
1442	Kharkov	162	40	35.2	50.9	11.3	44.0	27.3	48.6	56.2
782*	Fulcaster	154	37	18.3	39.3	.....	.....	18.3	39.3	46.6
2988	Dietz Amber	172	41	33.1	41.8	.....	42.1	13.3	42.0	31.5
1564	Pesterboden	143	38	19.3	50.0	9.3	49.0	14.3	49.5	28.8
784*	Powers' Fife	159	40	.....	.....	10.6	55.2	10.6	55.2	19.2
2239	Beloglina	181	44	22.4	50.0	.....	55.2	11.2	52.5	20.3
1127*	Hybrid 14a2 x c.	.....	....	44.2	44.2	.....	.....	44.2	44.2	100.0
1128*	Hybrid 362a3	.....	....	48.3	49.0	.....	.....	48.3	49.0	99.8

* California number.

Fig. 24.—Chul wheat, natural size.

SOME PROMISING NEW VARIETIES OF WHEAT FOR CALIFORNIA.

Of the many varieties of wheat tested during the last five years, the following varieties have shown the most promise and are recommended for trial by California farmers.

CHUL WHEAT.

Origin and History.—This wheat was first brought to this country by Mr. E. A. Bessey for the office of Seed and Plant Introduction in 1902. The University secured the first seed from this source. Of this variety the following notes were made by Mr. Bessey:

"Chul is grown on the steppes of Russia without irrigation. The grains are hard, but it is not durum wheat. This variety yields two harvests a year, for it can be sown as either a winter or spring wheat. If the former, the harvest comes in July; if the latter, the harvest comes in September. If sown in the spring, it is sown just as soon as the snow melts. The spring sowing is most certain to yield a good crop, for the fall sowing must depend upon the rather uncertain snows. This seed, however, is from the fall-sown seed. It is selected from over 1,000 pounds offered for sale, and is remarkably clean and free from foreign seeds for this region."

The Station distributed its first seed of this variety to farmers in October, 1903. The reported yields from these plantings were about 20 bushels per acre. Most of these small seedings were lost from one cause or another.

With the establishment of the Cereal Stations under the control of the University in 1904 and 1905 this variety was put into the variety test with others. From these stations small lots of Chul have been sent out from time to time to reliable farmers to further test its adaptability.

As a result of these experiments conducted upon the University Farm at Davis and at other stations, the University is now ready to recommend the wide planting of Chul (California No. 598) wheat, especially in place of Club and Chili wheats in the Sacramento Valley. After a number of years' trial, both on the experimental grounds controlled by the University and in co-operation with many farmers, this wheat has been found to meet the extreme conditions of the Sacramento Valley exceedingly well, besides being of milling quality much superior to Club but probably not superior to White Australian. While the wheat is of the bearded type, yet it differs much from the other bearded wheats which California farmers have tried.

Description.—Chul wheat is an early, erect, and vigorous variety which grows to a height of three to four feet. The wheat stools well

Fig. 25.—Little Club wheat at University Farm, Davis.

Fig. 26.—Chul wheat at University Farm, Davis.

and produces heads which are medium long, tapering, and bearded. In appearance, the growing wheat plant much resembles the well-known Propo, but the berry is of a much different character, being darker and larger, as well as harder. One particularly desirable feature is its non-shattering character. It will stand the heavy winds of the Sacramento Valley with scarcely any loss from shattering. The kernels are large, long, and tapering, and of a translucent character. The kernels are much harder and heavier than White Australian. They resemble the kernels from the durum wheats, although *the wheat is not a durum.* As indicated in the original notes, the variety is one that has a long seeding period and *it can be planted as late as the middle of February and still make a good crop.* As originally introduced it carried two types of heads and two types of kernels. One type possessed a white chaff, and the other a reddish brown chaff. The one type of kernel was light amber in color, and the other a reddish amber. Both of these types are still to be found in the commercial plantings of the last few years. *There is practically no Chul of a single pure type upon the market.* The Station has now separated the two types, and will send out no more of the mixed types. *Farmers who desire to secure a pure type of Chul are invited to correspond with the Station to that end.* In its ability to withstand drought it is a strong rival of the durum wheats. For instance, on one of the experiment stations of the University of California in 1908 it yielded at the rate of 63.3 bushels per acre and received less than eight inches of rainfall and was not irrigated. On another station the yield was at the rate of 63½ bushels per acre, with only ten inches of rain, and on still another station, at the rate of 51 bushels per acre.

Yields.—Chul wheat has made an exceptionally good showing in the field tests both on the Stations and in the field trials of farmers.

It has been tried, not only by the University of California, but also on a large scale by a considerable number of farmers in the vicinity of Williams, Arbuckle, and Maxwell during the past three seasons, under rather adverse conditions, and has given uniformly good results, although it had no rain after March 1st. In that section some 3000 acres of this wheat was grown in 1909, and a still larger acreage the past season.

REPORTS FROM FARMERS, 1910 CROP.

Through the medium of the University 161,082 pounds of this seed were distributed in 1909-10, and the reports upon the crop, so far as received, have been uniformly favorable and a much larger quantity was sold by growers directly.

Some of the growers report as follows:

No. 1; Woodland: Yield 12 sacks per acre. Will seed again this fall. "I think it is a very fine wheat. The north wind shrunk all grains except Chul."

No. 2; Dixon: Seeded in February. Yield 10 to 11 sacks per acre.

No. 3; Crows Landing: Seeded early in January. Received only 1½ inches of rain after seeding. Yield 16 sacks per acre. White wheat under same conditions made 12 sacks per acre.

No. 4: Seeded December 23. Yield 12 sacks per acre. Not so much pinched as other varieties.

No. 5; Newman: Seeded last of February. Yield 12.8 sacks per acre. Club seeded 15 days earlier gave 7 sacks.

No. 6; Waterford: Seeded last of December. Yield 8½ sacks per acre. Golden Gate Club under same conditions gave 5½ sacks per acre.

No. 7; San Miguel: Seeded December 15th. Yield 31.6 bushels per acre. Propo yield, under same conditions, 26.6 busnels per acre.

No. 8; Modesto: Average yield 13 sacks per acre on land considered worn out for wheat. "Even at high price paid for seed it has proven to be the cheapest I ever put in the ground."

No. 9; Collinsville: Grew 28 sacks from 300 pounds. Did not have a fair chance.

No. 10; Lynch: Yield 20 sacks per acre. White Australian under same conditions gave 14.3 sacks. Seeded December 20th.

No. 11; Orland: Yield 4 sacks per acre. White wheats about the same. Hot north winds seriously affected both crops.

No. 12; Walnut Creek: Seeded December 1st. Yield 15 sacks per acre. Other wheats on somewhat poorer land gave three sacks.

No. 13; Newman: Seeded December 1st. Yield 8 sacks per acre on rather poor land.

No. 14; Modesto: Yield 10 sacks per acre. White Australian 8 sacks.

No. 15; Hames: Propo and Chul both burned out by drought.

No. 16; Parkfield: Seeded December 2d. Yield 18.5 sacks per acre. White Australian seeded same day 15 sacks.

No. 17; Estrella: Seeded latter part of January. Yield 8 sacks per acre. "Seeded under very unfavorable conditions: ground too wet at the time of seeding and the weather was very unfavorable after that."

No. 18; Le Grand: Yield 11.7 sacks per acre. White Australian seeded about the same time yielded between 7 and 8 sacks. Seeded first part of January.

No. 19; Aptos: Yield 18 bushels on little less than an acre. Seeded about November 15th.

No. 20; Sacramento: Yield 13½ sacks per acre. The Chul came up stronger and was more vigorous all through the growing season than Club wheat sown under the same conditions alongside of it. Seeded about November 1st.

No. 21; Oakdale: "In a general way, will say that the Chul wheat has turned out better than Australian in this section. We are somewhat disappointed in some of the gluten tests. The wheat shows a great variation, some of it is very strong and some very weak."

No. 22; Hanford: Average yield 10 to 11 sacks per acre. Sonora wheat sown at the same time and under similar conditions yielded from 5 to 7 sacks.

No. 23; Concord: Yield 16 sacks per acre. "This I consider very good, as most wheat in this locality yields from 5 to 10 sacks per acre. Taking it all around, if the wheat produces like this every year it has no comparison with other wheats." Drilled on November 16th.

No. 24; Belmont: "Practically no yield of wheat. In March the field looked like a flower garden. Did not attempt to grow other grain."

No. 25; Lincoln: Yield 10.7 sacks per acre. Other wheat yielded 8.56 sacks per acre. Seeded October 20th.

No. 26; McArthur: "The Chul wheat gave promise of a good crop, but grasshoppers completely cleaned it up."

No. 27; Rio Vista: Yield 7 sacks. No other wheat under same conditions. Seeded January 10th.

No. 28; Santa Ana: "While the returns (from Chul wheat) are very small, I am very much gratified with the result as compared with the performance of Sonora wheat which was planted under like conditions and at the same time."

No. 29; Los Angeles: Yield about 15 sacks per acre. Seeded latter part of January. Fretes wheat under the same conditions yielded about 10½ sacks per acre and did not stand the dry weather as well as Chul.

No. 30; Cohn Ranch, Red Bluff: "Yield about 11 sacks per acre. It is hard to thresh out and for this reason is a good grain for the Sacramento Valley. Sowed the latter part of February, and had very little rain thereafter. White Australian alongside yielded 8.5 sacks to the acre."

The Milling Quality.—While the average gluten (protein) content of Chul is about 1 per cent. higher than the wheats commonly grown in California, as shown by the following, yet the millers offer some objection to it because of its hardness and the fact that the volume of loaf obtained from the flour is slightly less than some other wheats. But to offset this, its yield of flour is somewhat greater and the absorptive capacity of the flour is higher.

The slightly less volume of loaf is probably due to the quality of the gluten rather than to the smaller quantity. Still flour made from Chul wheat will produce a very fair loaf of bread of excellent texture and exceptionally good flavor. That this is true has been demonstrated by numerous bakings made in our own laboratories, and by loaves baked for us by a commercial baker in Oakland. The following illustration shows the relative size, appearance, and texture of a loaf made from a straight Chul flour and a baker's blend flour made from a California wheat flour and an Eastern flour from which the trade is regularly supplied with bread.

Fig. 27.—Showing relative size and texture of loaves baked from a regular baker's blend flour, and a straight flour from Chul wheat.

TABLE XVII.—COMPARISON OF NITROGENOUS INGREDIENTS OF CHUL WHEAT AND OF THE COMMON CALIFORNIA WHEATS.

	Analyses No. of	In dry matter		
		Nitrogen	Protein	Gliadin
(1) White Australian	42			
Average		1.74	9.89	3.74
Maximum		2.36	13.42	6.74
Minimum		1.22	6.92	1.86
(2) Washington Bluestem	33			
Average		1.80	10.18	3.83
Maximum		2.53	14.40	6.30
Minimum		1.25	7.15	1.98
(3) Sonora	17			
Average		1.71	9.71	3.48
Maximum		2.78	15.80	7.53
Minimum		1.34	7.59	2.26
(4) Propo	5			
Average		1.88	10.64	4.44
Maximum		1.92	11.94	5.39
Minimum		1.58	8.97	3.31
(5) Little Club	52			
Average		1.65	9.35	3.43
Maximum		2.40	13.64	6.24
Minimum		1.29	7.38	2.43
(6) Chul	55			
Average		1.91	10.84	3.35
Maximum		2.52	14.32	6.20
Minimum		1.36	6.73	1.46

The milling character of Chul will differ with individual lots according to its condition of culture, mainly time of seeding and the time at which it receives moisture. This is true of all varieties of wheat, and Chul is no exception in this case. Each lot should be judged upon its own merits as should all other wheats.

The wheat is considerably harder than the other types of wheat now handled by the millers, and the most economical method of handling the variety will have to be learned by further experience.

PROTEIN CONTENT OF WHEAT AS AFFECTED BY THE TIME OF OF SEEDING.

A large number of analyses of many varieties of wheat seeded both early and late have been made at the University laboratories and almost without exception it has been found that late planted wheat, while giving a smaller yield, produces a higher protein content. The

details of this work will be presented in a later publication. We present here, however, a contrast of early and late seeding of Chul and Fretes varieties grown on the California Station grounds as shown in Bulletin No. 178 of the United States Department of Agriculture.

TABLE XVIII—EFFECT OF THE LENGTH OF GROWING AND FRUITING PERIODS ON THE PROTEIN CONTENT OF THE CHUL AND FRETES WHEAT VARIETIES.

Grain Investigations No.	Variety	Length of Growing Period	Length of Fruiting Period	Protein*	Yield to the acre
2227	Chul	171	46	11.06	53.33
2227	do	151	41	12.43	52.89
1596	Fretes	177	45	10.94	56.00
1596	do	152	40	14.08	45.53

*The percentages of protein were obtained by multiplying the percentage of nitrogen by 5.7.

FRETES WHEAT.

Origin and History.[1]—Seed of Fretes wheat was received by the Office of Seed and Plant Introduction of the United States Department of Agriculture on September 26, 1901, from El-Outaya, Constantine, Algeria. It was obtained by Messrs. D. G. Fairchild and C. S. Scofield, who make the following notes on it:

"This variety, sometimes called Freitiss, is one of the few soft wheats grown in Algeria. It is particularly noted for its early maturity and is often extensively planted in the Sahara Desert in seasons when the winter rains occur so late that the durum varieties usually grown would not have time to mature. When planted in November, as it is in Algeria, at the same time with durum varieties, it is said to ripen two months in advance of them. The seed obtained was grown upon the rather salty desert sands in the vicinity of El-Outaya, north of Biskra, and watered with somewhat alkaline but still drinkable irrigation water. The variety is said to have originated from a shipment of Russian wheat which was made into Algeria at the time of a famine many years ago. Its early-maturing qualities attracted attention, and it has been cultivated in small quantities by the Arabs ever since."

Fretes wheat was first obtained by the Station in 1902 from the Seed and Plant Introduction Office and at once distributed to a few farmers in California, and good reports of its performance were received. It was placed in variety tests in the Station Experimental

[1] Bulletin 66, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1905, p. 151.

grounds in Sutter and Stanislaus counties in 1904-05, and has been grown on the testing stations ever since.

Description.—Fretes wheat is a free-stooling, prolific, semi-erect, vigorous, early, bearded wheat that should be seeded not later than January. It grows to a height of 3 to 4½ feet and stools fairly freely. The chaff does not inclose the grain as closely as that of the Chul, but compares well with White Australian in this respect. The kernels are of medium size and length, plump, and of a reddish color. They are much softer than those of Chul wheat.

Yields.—The observations made as to its adaptability to California conditions indicate that it is a heavier yielding variety than White Australian and is of fair milling quality.

The average yield of Fretes wheat as compared with White Australian under the same conditions on the University Stations is as follows:

	Stanislaus County	Yolo County
Fretes	46.5	42.7
White Australian	35.9	40.7

It has not been grown to any extent in acreage by farmers.

Milling Test.—A mill test of this wheat was made by the Oakdale Milling Company, Oakdale, California, which indicated that this variety was of a free milling character, and that the flour from the sample milled possessed a 40 per cent. wet gluten content against 38 per cent. for the White Australian milled at the same time and grown under the same conditions.

Fig. 28.—Fretes wheat, full size.

A BRIEF STATEMENT OF THE ESSENTIALS FOR SUCCCESS IN GRAIN CULTURE.

1.—The minimum limit of precipitation for successful culture is about eight inches.

2.—When the precipitation is less than fifteen inches bi-ennial cropping, summer-fallowing, should be practiced.

It saves as much as possible of two seasons' rain for one crop.

It kills weeds which use up moisture, plant food, and increases the cost of operation.

It increases aeration, and makes plant food more available.

But it is destructive of humus, which must be restored by green-manuring.

3.—Add organic matter to the soil by turning under winter-grown rye, field peas or some other leguminous crop.

This improves the mechanical condition of the soil.

It enables it to hold more moisture.

It helps to make plant food more available.

It lessens washing, drifting and blowing of soils.

4.—For fall preparation of grain land plow not less than eight inches deep.

This enables rain to get into the soil easily.

It prevents run-off in case fo very heavy rain.

It provides more feeding space for plant roots.

It encourages deep rooting of plants.

It makes more plant food available.

5.—On light land sub-pack the soil immediately after plowing, using either a sub-packer or a disc-harrow.

This fills up air spaces in the furrow.

It gives a compact lower soil which brings moisture up to the plant roots.

It leaves the surface soil loose; the lower soil compact.

The press-wheels firm the soil about the seed, and hasten germination.

6.—Harrow to a good mulch or seed-bed immediately following the packer.

This prevents rapid evaporation of moisture, and provides a good seed-bed for quick germination.

7.—Seed with a drill with press-wheel attachment.

It distributes the seed evenly over the land.

It places the seed all beneath the surface of the soil at a uniform depth.

It requires less seed.

8.—Select large, vigorous, plump kernels of grain.

These have greater vitality and a greater reserve supply of plant food, thus producing more vigorous plants.

9.—Harrow the grain after it is well up.

This serves to retain moisture.

10.—Disc the land as soon as possible after the crop is off.

This tends to save residual moisture and gives a fine earth to turn under in the first plowing.

11.—In case of summer-fallow practice maintain a clean, well-cultivated soil mulch during the summer.

These all make for success in dry land farming.

STATION PUBLICATIONS AVAILABLE FOR DISTRIBUTION.

REPORTS.

1896. Report of the Viticultural Work during the seasons 1887-93, with data regarding the Vintages of 1894-95.

1897. Resistant Vines, their Selection, Adaptation, and Grafting. Appendix to Viticultural Report for 1896.

1902. Report of the Agricultural Experiment Station for 1898-1901.

1903. Report of the Agricultural Experiment Station for 1901-03.

1904. Twenty-second Report of the Agricultural Experiment Station for 1903-04.

BULLETINS.

Reprint. Endurance of Drought in Soils of the Arid Region.

No. 128. Nature, Value, and Utilization of Alkali Lands, and Tolerance of Alkali. (Revised and Reprint, 1905.)

133. Tolerance of Alkali by Various Cultures.

147. Culture Work of the Sub-stations.

149. California Sugar Industry.

151. Arsenical Insecticides.

152. Fumigation Dosage.

153. Spraying with Distillates.

154. Sulfur Sprays for Red Spider.

159. Contribution to the Study of Fermentation.

161. Tuberculosis in Fowls. (Reprint.)

162. Commercial Fertilizers. (Dec. 1, 1904.)

165. Asparagus and Asparagus Rust in California.

167. Manufacture of Dry Wines in Hot Countries.

168. Observations on Some Vine Diseases in Sonoma County.

169. Tolerance of the Sugar Beet for Alkali.

170. Studies in Grasshopper Control.

171. Commercial Fertilizers. (June 30, 1905.)

172. Further Experience in Asparagus Rust Control.

174. A New Wine-cooling Machine.

176. Sugar Beets in the San Joaquin Valley.

177. A New Method of Making Dry Red Wine.

178. Mosquito Control.

179. Commercial Fertilizers. (June, 1906.)

180. Resistant Vineyards.

181. The Selection of Seed-Wheat.

182. Analysis of Paris Green and Lead Arsenic. Proposed Insecticide Law.

183. The California Tussock-moth.

No. 184. Report of the Plant Pathologist to July 1, 1906.

185. Report of Progress in Cereal Investigations.

186. The Oidium of the Vine.

187. Commercial Fertilizers. (January, 1907.)

188. Lining of Ditches and Reservoirs to Prevent Seepage and Losses.

189. Commercial Fertilizers. (June, 1907.)

190. The Brown Rot of the Lemon.

191. California Peach Blight.

192. Insects Injurious to the Vine in California.

193. The Best Wine Grapes for California; Pruning Young Vines; Pruning the Sultanina.

194. Commercial Fertilizers. (Dec., 1907.)

195. The California Grape Root-worm.

197. Grape Culture in California; Improved Methods of Wine-making; Yeast from California Grapes.

198. The Grape Leaf-Hopper.

199. Bovine Tuberculosis.

200. Gum Diseases of Citrus Trees in California.

201. Commercial Fertilizers. (June, 1908.)

202. Commercial Fertilizers. (December, 1908.)

203. Report of the Plant Pathologist to July 1, 1909.

204. The Dairy Cow's Record and the Stable.

205. Commercial Fertilizers. (December, 1909.)

206. Commerical Fertilizers. (June, 1910.)

207. The Control of the Argentine Ant.

208. The Late Blight of Celery.

209. The Cream Supply.

210. Imperial Valley Settlers' Crop Manual.

CIRCULARS.

No. 1. Texas Fever.
3. Hog Cholera.
5. Contagious Abortion in Cows.
7. Remedies for Insects.
9. Asparagus Rust.
10. Reading Course in Economic Entomology. (Revision.)
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No. 36. Analyses of Fertilizers for Consumers.
39. Instruction in Practical Agriculture at the University Farm.
46. Suggestions for Garden Work in California Schools.
47. Agriculture in the High Schools.
48. Butter Scoring Contest, 1909.
49. Insecticides.
50. Fumigation Scheduling.
51. University Farm School.
52. Information for Students Concerning the College of Agriculture.
53. Announcement of Farmers' Short Courses for 1910.
54. Some Creamery Problems and Tests.
55. Farmers' Institutes and University Extension in Agriculture.
57. Announcement of Farmers' Short Courses in Animal Industry and Veterinary Science.
58. Experiments with Plants and Soils in Laboratory, Garden, and Field.